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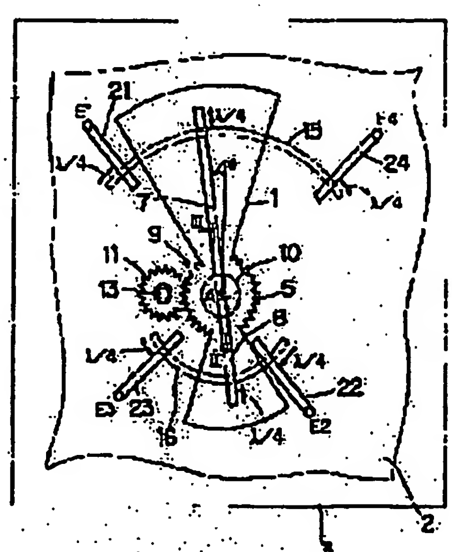
(54) DISTRIBUTION VARIABLE PHASE SHIFTER

(57)Abstract:

PURPOSE: To provide a distribution variable phase shifter which can distribute the electric power and then can continuously vary the phase of distributed signals in a simple and highly reliable constitution.



CONSTITUTION: A rotary substrate 1 can relatively turn to a fixed substrate 2 and is provided with input strip lines 7 and 8 to distribute the high frequency signals received through an input terminal A into two groups. Meanwhile the substrate 2 is provided with arc-shaped slot lines 15 and 16 of different radiuses, and the output strip lines 21, 22, 23 and 24 are connected to both ends of lines 15 and 16 respectively. The high frequency signals supplied through the terminal A are distributed to the output terminals E1-E4. When the substrate 1 is turned, the lengths of transmission lines led to the terminals

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shifted variable is continuously varied. Furthermore the signals of difference phases are taken out of the terminals E1-E4 and at the same time the phase differences can be varied among the signals in accordance with turning of the substrate 1.

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CLAIMS

[Claim(s)]
[Claim 1] The distribution adjustable phase shifter which has the 1st substrate and the 2nd substrate which are characterized by providing the following, and which can be rotated relatively [circumference / of a predetermined axis]. The 1st substrate of the above is the input edge prepared on the above-mentioned axis. They are n circular slot lines which have the input stripline of n (n= 1, 2, 3 and 4, ...) book which branched from this input edge, and are sharing the center on the above-mentioned predetermined axis while the 2nd substrate of the above is combined with n above-mentioned striplines, respectively. 2n output stripline combined with each ends of these n circular slot lines, respectively.
[Claim 2] n above-mentioned circular slot lines are distribution variable-phase machines according to claim 1 characterized by having a radius which is mutually different.
[Claim 3] For n above-mentioned circular slot lines, the ratio of a radius is 1:3:5..: .... It is the distribution adjustable phase shifter according to claim 2 characterized by being formed so that it may become : (2n-1).
[Claim 4] The distribution adjustable phase shifter according to claim 1 to 3 characterized by including further the rotary joint which combines between the above-mentioned input edge and feeders in the state of permitting relative rotation of the circumference of the above-mentioned predetermined axis.
[Claim 5] The distribution adjustable phase shifter according to claim 1 to 4 characterized by including further the rolling mechanism for rotating relatively [circumference / of the above-mentioned predetermined axis] the 1st substrate of the above, and the 2nd substrate, and the control unit for giving turning effort to this rolling mechanism.
[Claim 6] The distribution adjustable phase shifter according to claim 1 to 5 characterized by infixing the impedance converter in the above-mentioned input stripline, the above-mentioned output stripline, or the above-mentioned circular slot line.
[Claim 7] The distribution adjustable phase shifter according to claim 1 to 5 characterized by establishing an impedance matching circuit in the above-mentioned input edge.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the distribution adjustable phase shifter to which the phase of the distributed signal can be changed continuously while being able to perform power distribution of a RF signal. By using this distribution adjustable phase shifter, the beam tilt angle of the array antennas used for example, in a mobile communications base station can be changed electrically.
[0002]
[Description of the Prior Art] In order to change the beam tilt angle of array ANNATE, the feeder system which changes the length of the cable which supplies electric power to each array-antennas element in the RF signal distributed with the power distribution unit, and changed the phase distribution of the high frequency current to which electric power is supplied by array antennas by this is used.
[0003]
[Problem(s) to be Solved by the Invention] Although the amount of phase shifts of a RF signal will be set up with the length of a cable in such a feeder system, when it is going to change the amount of phase shifts, a cable is removed from a connector, and it exchanges for the cable with which length is different, or the cable itself is shortened, and the complicated work of attaching a connector again is needed, for example. Especially, when a feeder system is installed in the outdoors, since water proofing is performed to a connector area, you also have to do each work of removal of the water-proofing section, and anchoring.
[0004] Moreover, in order to change the beam tilt angle of array antennas, the length of a cable is made the same and what infixed the phase shifter between a power distribution unit and array antennas is used. With this composition, if it is going to change a phase in a continuous or fine pitch, while many switches and cables will be needed and the size of a feeder system will become large, cost also increases. And since the above-mentioned switch has the Mechanical contact, it may start a poor contact by secular change, and has a possibility of producing an intermodulation and noise.
[0005] Then, the purpose of this invention is offering the distribution adjustable phase shifter to which the phase of the distributed signal can be changed continuously while it solves an above-mentioned technical technical problem and can distribute power by easy and reliable composition.

[0006]
[Means for Solving the Problem and its Function] The distribution adjustable phase shifter according to claim 1 for attaining the above-mentioned purpose It is the distribution adjustable phase shifter which has the 1st substrate and the 2nd substrate which can be rotated relatively [circumference / of a predetermined axis]. the 1st substrate of the above It has the input edge prepared on the above-mentioned axis, and the input stripline of n (n= 1, 2, 3 and 4, ...) book which branched from this input edge. the 2nd substrate of the above While being combined with n above-mentioned striplines, respectively, it is characterized by having n circular slot lines which are sharing the center on the above-mentioned predetermined axis, and 2n output stripline combined with each ends of these n circular slot lines, respectively.
[0007] According to this composition, if a RF signal is given to the input edge of the 1st substrate, after this RF signal is distributed to n input striplines, it will be given to n circular slot lines formed in the 2nd substrate, and will be further given to the output stripline combined with the ends of each circular slot line. By this, 2n of inputted RF signals will be distributed.
[0008] If the 1st substrate and the 2nd substrate are rotated relatively [circumference / of a predetermined axis], the transmission path length which results in an output stripline will change from an input edge corresponding to the rotated angle and the radius of a circular slot line. Since the amount of phase shifts of a RF signal is set up corresponding to this transmission path length, the amount of phase shifts can be continuously changed by rotating the 1st substrate and the 2nd substrate relatively.
[0009] A distribution adjustable phase shifter according to claim 2 is characterized by n above-mentioned circular slot lines having a mutually different radius. According to this composition, since n circular striplines have a mutually different radius, the change of the above-mentioned transmission path length accompanying relative rotation with the 1st substrate and the 2nd substrate differs for every output stripline. Therefore, the phase contrast between the signals taken out from 2n output stripline can be changed continuously.
[0010] For n above-mentioned circular slot lines, the ratio of a radius is [a distribution adjustable phase shifter according to claim 3] 1:3:5. : .... It is characterized by being formed so that it may become : (2n-1). According to this composition, the variation of the transmission path length from the input edge accompanying relative rotation of the 1st substrate and the 2nd substrate to each output stripline can be set up in the shape of a taper. That is, the RF signal given to the input edge can be distributed to 2n signal which has Taber-like phase contrast.
[0011] In addition, it is desirable to have the rotary joint which combines between the above-mentioned input edge and feeders in the state of permitting relative rotation of the circumference of the above-mentioned predetermined axis as indicated by the claim 4. Moreover, it is desirable to have a rolling mechanism for rotating relatively [circumference / of the above-mentioned predetermined axis] the 1st substrate of the above and the 2nd substrate and a control unit for giving turning effort to this rolling mechanism as indicated by the claim 5.
[0012] Furthermore, what is necessary is to infix an impedance converter in the above-mentioned input stripline, the above-mentioned output stripline, or the above-mentioned circular slot line, to establish an impedance matching circuit in (a claim 6)

the impedance of an input edge and the outgoing end of the edge of an output stripline.

[0013]
[Example] Below, the example of this invention is explained in detail with reference to an accompanying drawing. Drawing 1 is the plan showing the composition of the distribution adjustable phase shifter of one example of this invention. This distribution adjustable phase shifter is equipped with the rotation substrate 1 as the 1st substrate, and the fixed substrate 2 as the 2nd substrate. It is attached so that the fixed substrate 2 may be fixed to the shielding case 3 shown by the imaginary line and the rotation substrate 1 can be freely rotated to the circumference of the predetermined axis 5 to the fixed substrate 2.

[0014] The rotation substrate 1 consists of insulators and the input striplines 7 and 8 prolonged in the direction which deserts an axis 5 are formed in the front face. Electric power is supplied to a RF signal by the input striplines 7 and 8 from the input edge A through the input section 10 prepared behind the fixed substrate 2. The conductor is not formed in the rear face of the rotation substrate 1. The rotation substrate 1 has the gearing section 9 around the axis 5. This gearing section 9 gears with the gearing 11 held free [rotation] to the fixed substrate 2, and is in it. The knob 13 as a control unit which projects out of a shielding case 3 is being fixed to the gearing 11, and the rotation substrate 1 can be rotated by rotating this knob 13. That is, the rolling mechanism is constituted by the gearing section 9, the gearing 11, etc.

[0015] The fixed substrate 2 consists of insulators and the conductor is mostly formed in the rear face on the whole surface. The slot lines 15 and 16 of a couple are formed by removing a part of this conductor circularly. The circular slot lines 15 and 16 share a center on an axis 5, and they are circularly formed so that the ratio of a radius may be set to 3:1. Each point has combined with the slot lines 15 and 16 the above-mentioned input striplines 7 and 8 prepared in the rotation substrate 1, respectively. That is, the input striplines 7 and 8 are set up so that the ratio of length may be set to about 3:1. Specifically, a point is prolonged to the position which deserted the axis 5 rather than the slot lines 15 and 16 only lambda/4 (wavelength of the electric wave by which electric power is supplied to lambda), and the input striplines 7 and 8 are formed.

[0016] four output striplines 21 combined with the front face of the fixed substrate 2 to each both ends of the slot lines 7 and 8, respectively, and 24; -- 22 and 23 are formed if it furthermore explains to a detail -- the output stripline 21 and 24; -- 22 and 23 lie at right angles [in / an inside position / only in lambda/4] to the slot lines 7 and 8 mostly from each ends of the slot lines 7 and 8 The output striplines 21, 22, 23, and 24 all have equal length.

[0017] Drawing 2 is a cross section for explaining the integrated state of the input stripline 7 formed in the front face of the rotation substrate 1, and the circular slot line 15 formed in the rear face of the fixed substrate 2. The rotation substrate 1 and the fixed substrate 2 are in slide contact, and combination with the input stripline 7 and the circular slot line 15 is attained through the substrates 1 and 2 which consisted of these two insulators. 18 is the conductor formed in the rear face of the fixed substrate 2. In addition, it is the same also about combination with the input stripline 8 and the slot line 16.

which can be set and the composition of the input section 10 for supplying electric power to the input striplines 7 and 8 in a RF signal is shown. The cylinder-like bond-part material 25 is being fixed to the rear face (field which is in slide contact with the fixed substrate 2) of the rotation substrate 1 along with the axis 5, and this bond-part material 25 is electrically connected to the input striplines 7 and 8 through the connection material 26, such as solder. The bond-part material 25 is inserted in free [rotation of the hole 27 formed in the fixed substrate 2], and is further exposed outside from the hole 29 formed in the shielding case 3. The connector 33 for connecting the connector 31 connected to the coaxial cable as a feeder is attached in the marginal part of a hole 29. If outer-conductor 31e of the connector 31 by the side of a coaxial cable is inserted in a connector 33, inner conductor 31i of a connector 31 will enter the building envelope of the cylinder-like bond-part material 25. The gap 35 is formed between inner conductor 31i and the bond-part material 25.

[0019] By this composition, electric power can be supplied to the input striplines 7 and 8 through the bond-part material 25 and the connection material 26 in the RF signal given through a connector 31. And even if the bond-part material 25 rotates with rotation of the rotation substrate 1, since the integrated state of inner conductor 31i of a connector 31 and the bond-part material 25 is held eternally, noise etc. does not produce it at the time of the rotation. Thus, so to speak, the rotary joint is constituted by the cylinder-like bond-part material 25 and inner conductor 31i of a connector 31.

[0020] with the above composition, if electric power is supplied in a RF signal from the input section 10, 2 ****s of this signal will be made the input striplines 7 and 8 -- having -- further -- the slot lines 15 and 16 -- minding -- respectively -- the output stripline 21 and 24; -- 2 ****s is made 22 and 23 As the result, an input RF signal will be used as the outgoing ends E1, E2, E3, and E4 of the output striplines 21, 22, 23, and 24 4 ****s, and will be taken out.

[0021] For example, if rotation operation of the knob 13 is carried out and only an angle theta rotates the rotation substrate 1 counterclockwise, the transmission path length from the input section 10 to outgoing ends E1, E2, E3, and E4 will change as follows. That is, each transmission path length is set up in the shape of a taper. In addition, the radius of the circular slot line 15 is set to 3r (r is a constant), and the radius of the circular slot line 16 is set to r.

[0022]

E1 .... -3rthetaE2 .... - rthetaE3 .... rthetaE4 ....: The signal which has taper-like phase contrast will be taken out from each [3rtheta, therefore] outgoing ends E1-E4. Since an angle theta can be continuously changed by rotating a knob 13, the phase of the signal taken out from each outgoing ends E1-E4 can be changed continuously, and can also change the phase contrast between signals continuously.

[0023] Next, adjustment of an impedance is explained. Drawing 4 is drawing showing the characteristic impedance of each part. Namely, as for the input striplines 7 and 8, width of face is chosen so that a characteristic impedance may be set to 100 ohms. Moreover, width of face is set up so that a characteristic impedance may be set to 200 ohms, and as for the slot lines 15 and 16, width of face is chosen, as for the output striplines 21, 22, 23, and 24 so that a characteristic impedance may be set to 200 ohms. In this case, the impedance of the input edge A is set to 50 ohms, and each

adjustment of an impedance.
[0024] Drawing 5 is drawing simplifying and showing the example of composition for making each impedance of the input edge A and outgoing ends E1-E4 in agreement with 100 ohms. That is, each characteristic impedance of the input striplines 7 and 8, the slot lines 15 and 16, and the output striplines 21, 22, 23, and 24 is set to 100 ohms. And the quadrant wavelength impedance converter of root(50x100) omega is prepared in the section, respectively in the middle of the input striplines 7 and 8. Thereby, the impedance of the input edge A and outgoing ends E1-E4 can be arranged with 100 ohms.
[0025] As shown in drawing 6 , in addition, infix the quadrant wavelength impedance converter of root(50x100) omega in the section in the middle of the slot lines 15 and 16, or Also by infixing the quadrant wavelength impedance converter of root(50x100) omega in the section in the middle of [each] the output striplines 21, 22, 23, and 24, as shown in drawing 7 The impedance of the input edge A and outgoing ends E1-E4 can be made in agreement with 100 ohms. However, in drawing 6 and drawing 7 , the characteristic impedance of each part shall be set up like drawing 5 .
[0026] Furthermore, as simplified and shown in drawing 8 , you may aim at adjustment of an impedance by connecting with the input striplines 7 and 8 and forming the stub 30 as an impedance matching circuit. Although explanation of the example of this invention is as above, this invention is not limited to the above-mentioned example. For example, although the above-mentioned example explained the case where the inputted RF signal was carried out 4 ****s, two distributions, six distributions, and eight distributions are attained, respectively by making into 1, 3, 4, and .... the input stripline prolonged from an axis 5. In this case, it is [.... What is necessary is to consider as : (2n-1) and just to form in the fixed substrate 2 n circular slot lines combined with these n strip conductors.] the ratio of the length of n striplines About 1:3:5 : At this time, for n circular slot lines, the ratio of a radius is 1:3:5 while sharing a center on an axis 5. : .... It is desirable to be formed so that it may become : (2n-1). If it does in this way, the signal which has taper-like phase contrast can be taken out from the output stripline combined with the both ends of each slot line.
[0027] Moreover, although an input stripline is formed in a rotation substrate and the circular slot line and the output stripline are formed in a fixed substrate in the above-mentioned example, while forming an input stripline in a fixed substrate, you may form a circular slot line and an output stripline in a rotation substrate. Furthermore, both the 1st substrate in which the input strike RIFFU line was formed, and the 2nd substrate in which the circular slot line etc. was formed are good for mutual also as composition rotated to an opposite direction.
[0028] In addition, design changes various in the range which does not change the summary of this invention can be performed.
[0029]
[Effect of the Invention] Since a distribution adjustable phase shifter can be constituted using a stripline etc. as mentioned above according to this invention, composition becomes easy, and small lightweight-ization can be attained, and manufacture becomes easy. Moreover, since power distribution and a phase shift can be performed with the same composition, part mark decrease compared with carrying

starting a poor contact decreases.

[0030] Moreover, since the number of outputs can be easily changed by changing the number of input striplines, when applying to feeder systems, such as array antennas, it can respond to change of the number of antenna elements flexibly. Furthermore, it is very effective, if a service area is applied to the feeder system of array antennas with the need of changing at any time, like the antenna of a mobile communications base station, for example, since an adjustable setup of the amount of phase shifts of an input signal can be carried out easily.

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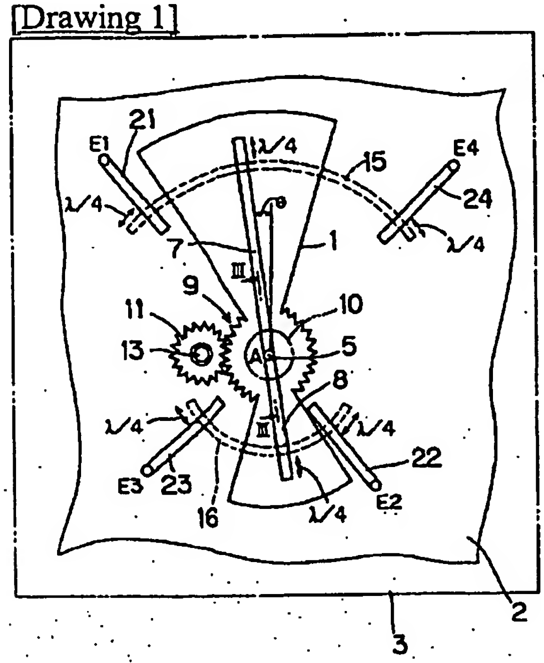
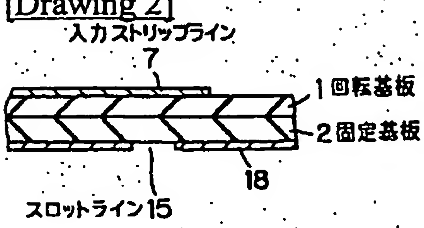
DRAWINGS

[Drawing 1]

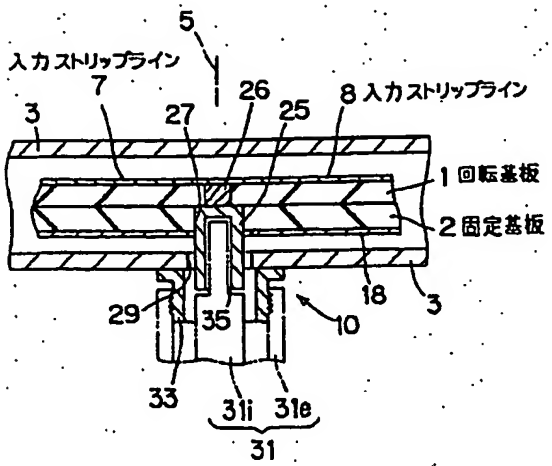


1…回転基板
2…固定基板
7,8…入力ストリップライン
15,16…スロットライン
21,22,23,24…出力ストリップライン

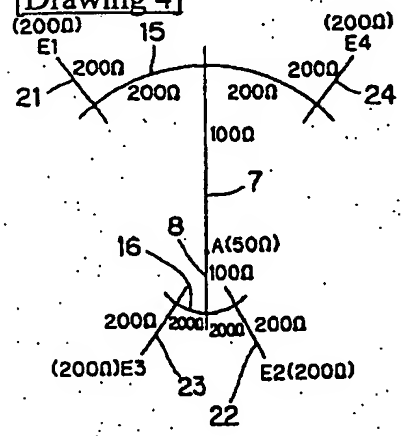
[Drawing 2]



[Drawing 3]

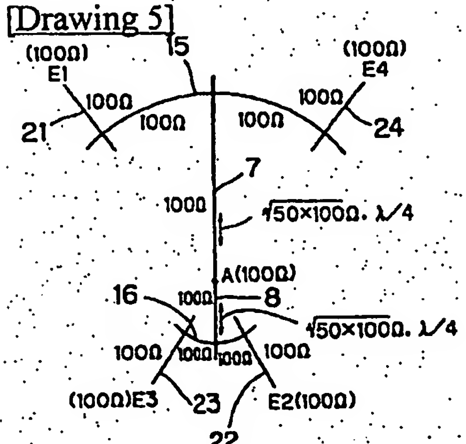


[Drawing 4]

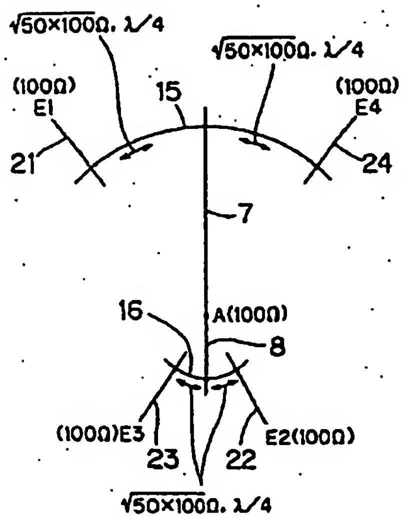


7.8…入力ストリップライン
15.16…スロットライン
21.22.23.24…出力ストリップライン

[Drawing 5]

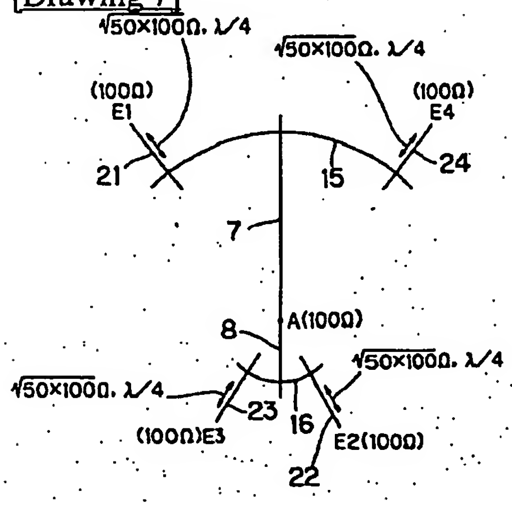


7.8…入力ストリップライン
15.16…スロットライン
21.22.23.24…出力ストリップライン



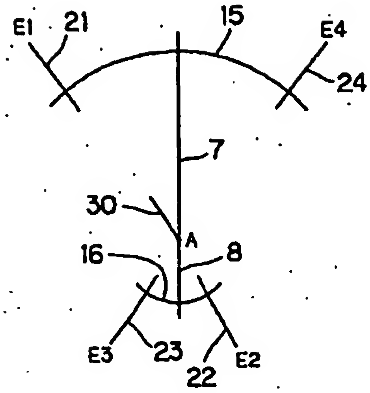
7,8…入力ストリップライン
15,16…スロットライン
21,22,23,24…出力ストリップライン

[Drawing 7]



7,8…入力ストリップライン
15,16…スロットライン
21,22,23,24…出力ストリップライン

[Drawing 8]



7.8…入力ストリップライン
15.16…スロットライン
21.22.23.24…出力ストリップライン

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